Compact Dual-Frequency Dual-Polarization Microstrip Antenna Feed for Future Soil Moisture and Sea Surface Salinity Missions

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Earth Science Technology Workshop

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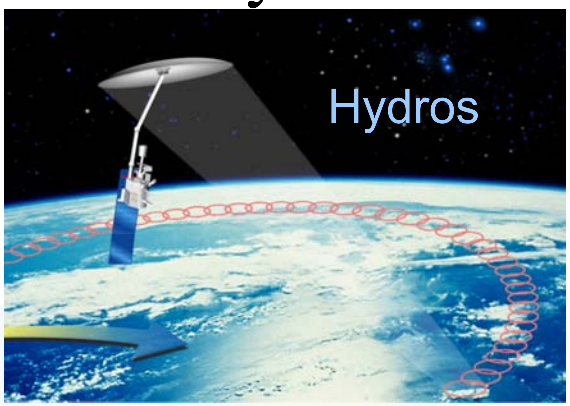
Outline

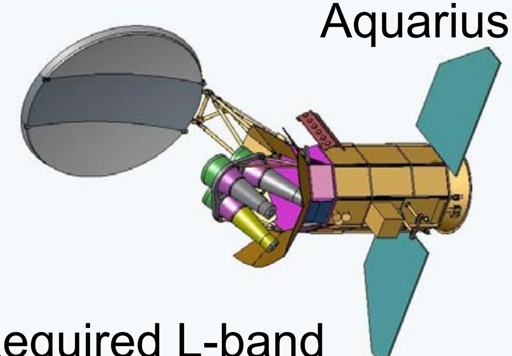
- Introduction
- Technical Development
  - Antenna Design and Testing
  - Antenna Fabrication
- Summary
- Future Work

Objectives

- Develop a compact dual-frequency antenna feed for future operational soil moisture and sea surface salinity missions



Aquarius

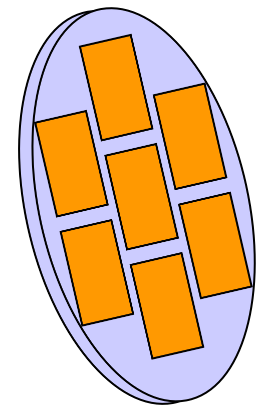


Required L-band
Radiometer (1.41 GHz)
And Radar (1.26 GHz)

Present Technology

Conical Feedhorn,
Orthomode Transducer,
and Frequency Diplexer
•1.2 m long
•15 kg mass
•Low loss (<0.5 dB)

New Technology
Compact and
Lightweight

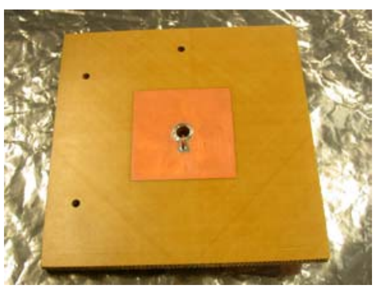


Stacked-Patch
Microstrip Patch
For Dual-Frequency
•>0.05 m profile
•>2 kg
•Honeycomb Korex
Core for Low Loss

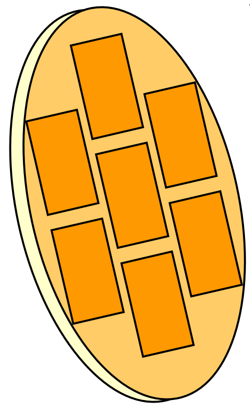
Development Plan

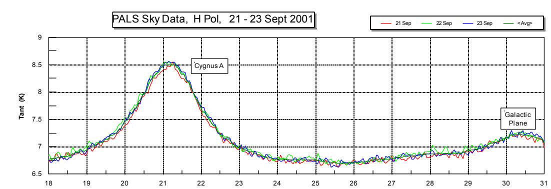
2003 | 2004 | 2005

- Design and testing of a single microstrip stacked patch to verify the dual-frequency design concept



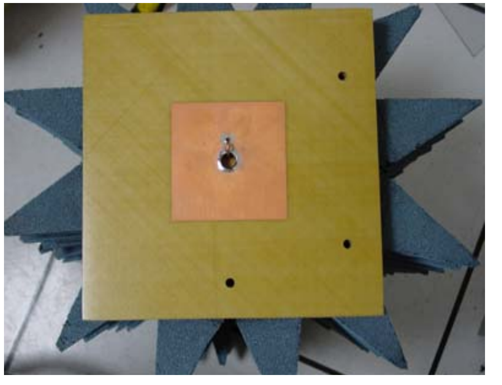
- Design, fabricate, and test the microstrip array
  - Return loss
  - Radiation pattern





- Measurements of the insertion loss of the MSPA using the cold sky

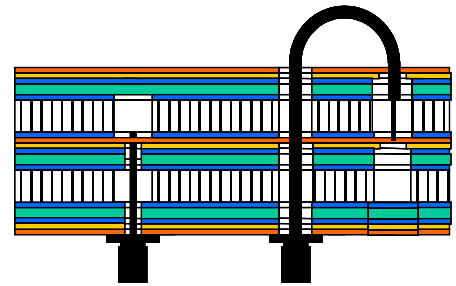
Antenna Design and Testing



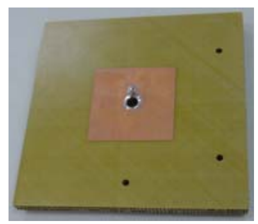
Design Methodology For Single-Element Stacked Patch

- Novel center-fed design and testing for single layer

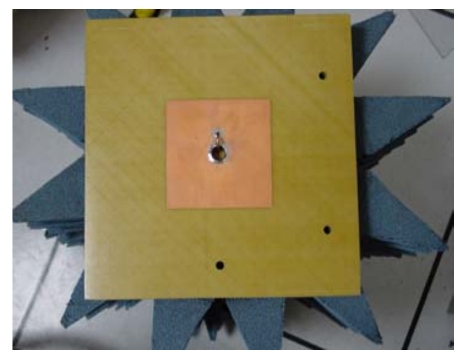
- FDTD Simulation of Single-Polarization Stacked Patch



- Fabrication of a Prototype

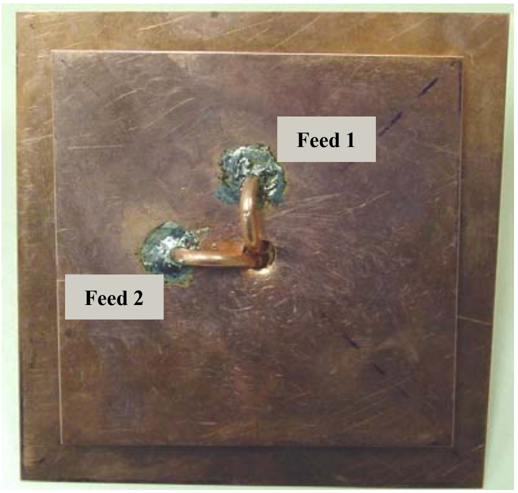


- Return Loss and Antenna Pattern Testing

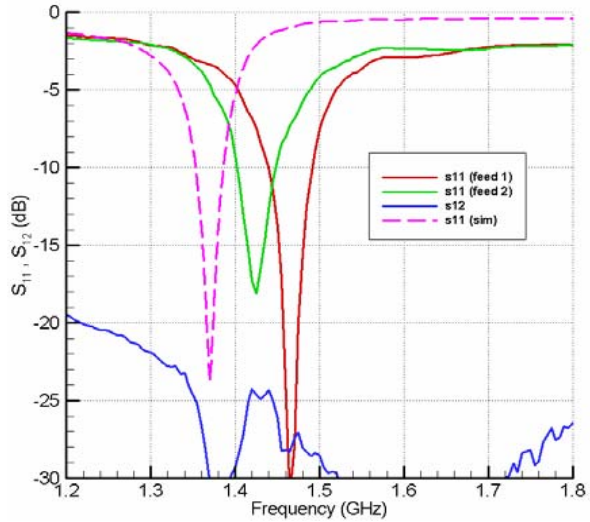


- Return Loss and Antenna Pattern Testing for Smaller Ground Plane

Dual-Polarized Center-Fed Microstrip Patch Antenna

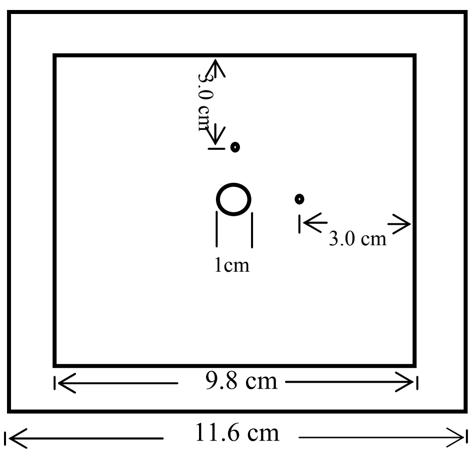


Dual-polarized patch with center-feeding

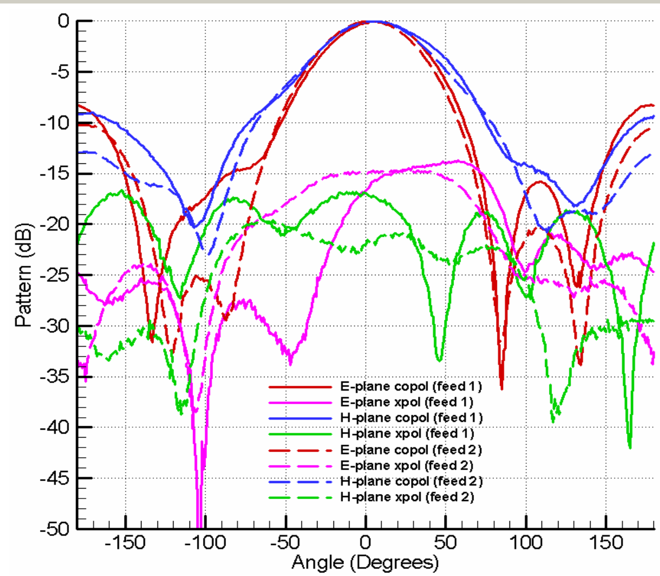


Return-loss and isolation results for dual-polarized patch

Measured resonant frequency feed 1: 1.425GHz
Bandwidth (VSWR 2:1) feed 1: 50MHz
Measured resonant frequency feed 2: 1.465GHz
Bandwidth (VSWR 2:1) feed 2: 40MHz



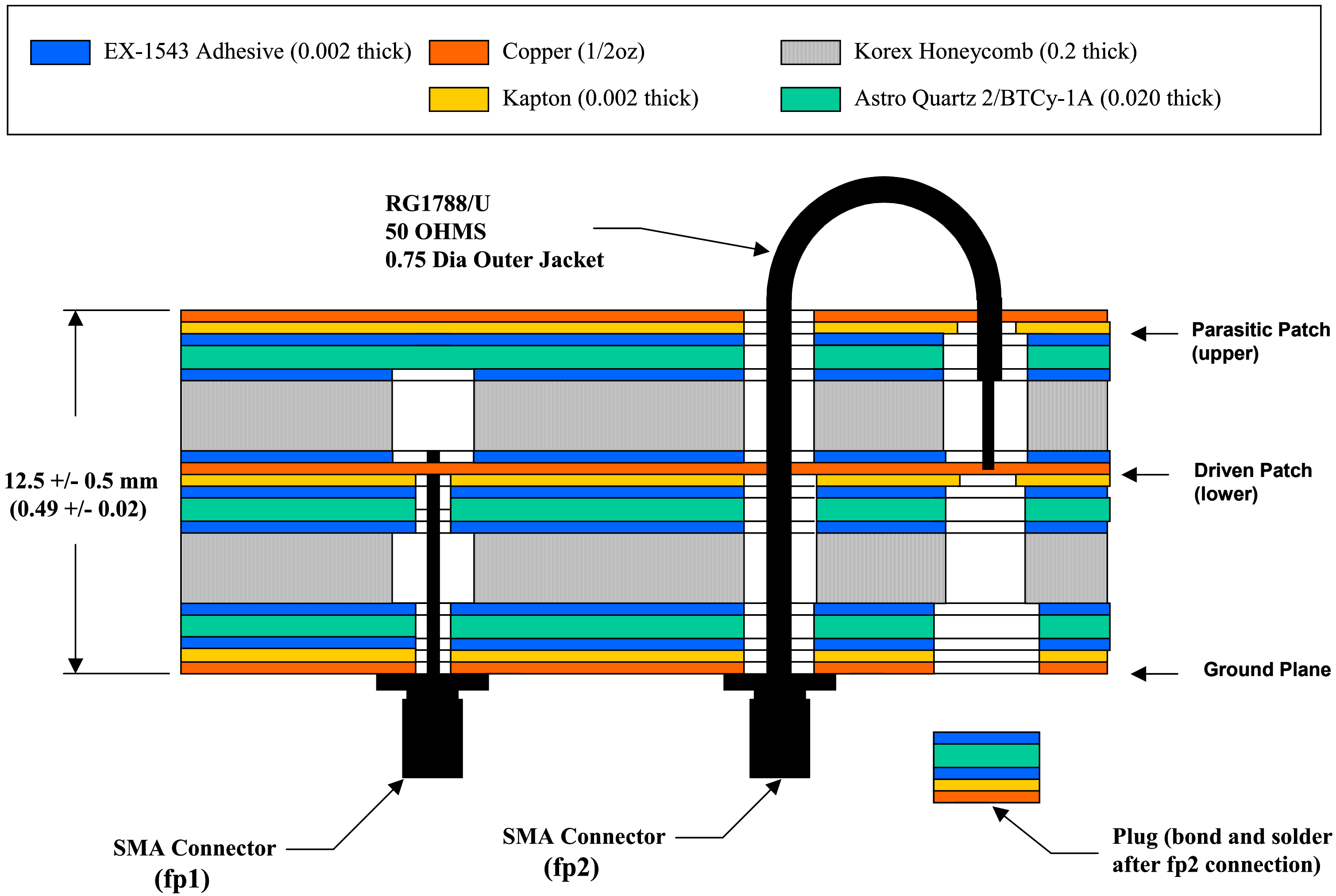
Dual-polarized patch parameters



Far-field radiation pattern for dual-polarized patch at the two feeds

- **The patch can be tuned to obtain resonant frequency of 1.414GHz**

Side-View of the Stacked Patch Showing the Various Layers

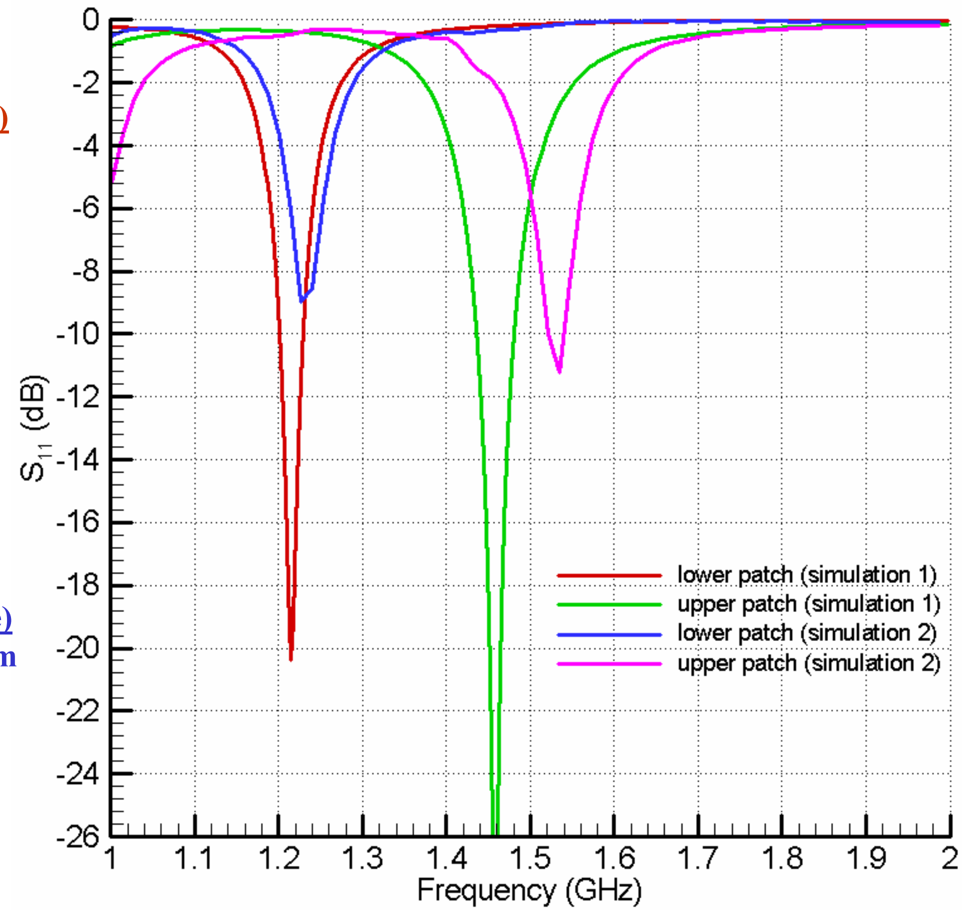


❖ The various layers were modeled using UCLA-FDTD code
❖ Effective parameters were calculated by taking weighted average for layers that were too thin

FDTD Simulation Results

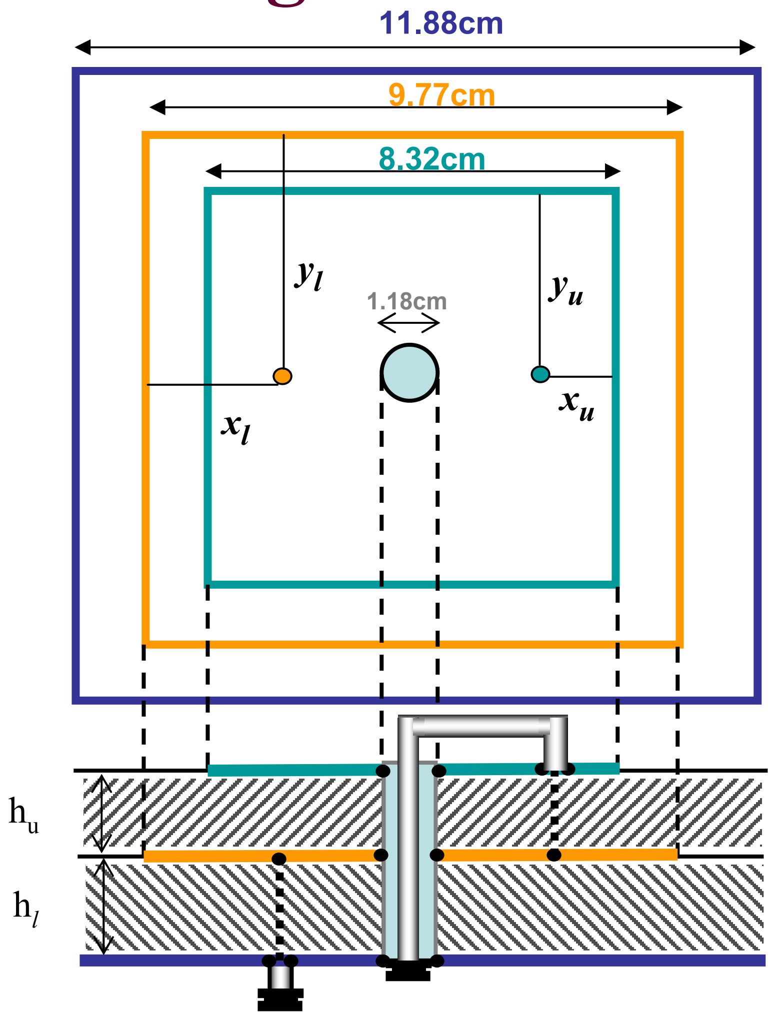
Simulation 1 (Fast computation with acceptable convergence)
Cell size: 0.29cm, Coax size: 0.58cm(dia), Size of tube: 1.2cm
Resonant frequency upper patch: 1.456GHz, S_{11} : -29.71dB
Resonant frequency lower patch: 1.213GHz, S_{11} : -20.38dB
Bandwidth- Upper patch: 46MHz
Lower patch: 27.2MHz

Simulation 2 (Slow computation with demanding convergence)
Cell size: 0.066cm, Coax size: 0.132cm(dia), Size of tube: 1.2cm
Resonant frequency upper patch: 1.534GHz, S_{11} : -11.23dB
Resonant frequency lower patch: 1.227GHz, S_{11} : - 8.96dB



Return-loss Simulation Results

Design Parameters of the Stacked Patch



Dimensions of the stacked patch with their feed points

Feed point of lower patch: (x_l, y_l) = (3.10cm, 4.88cm)
Feed point of upper patch: (x_u, y_u) = (2.70cm, 4.16cm)
Substrate heights: h_l = 6.4mm, h_u = 5.79mm

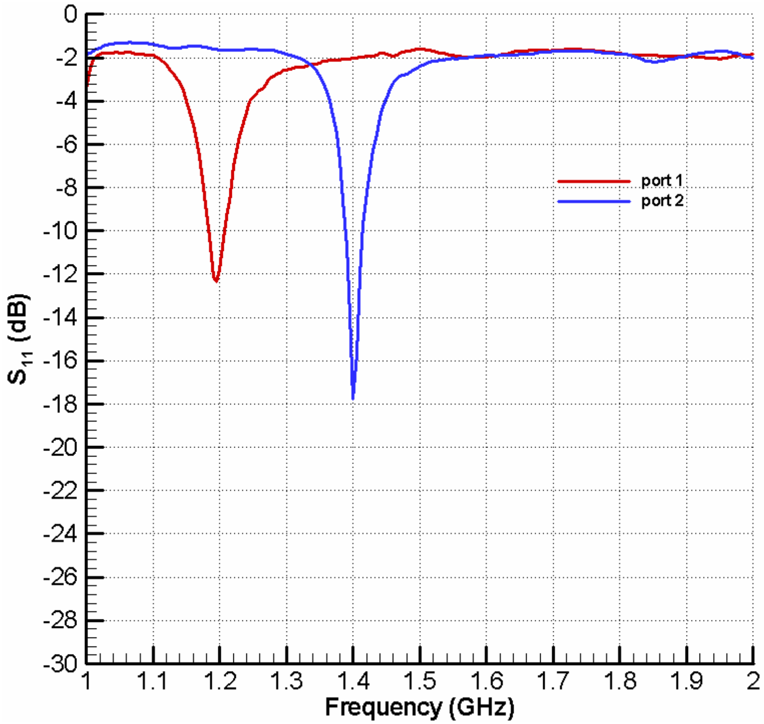
Picture of the Stacked-Patch built at JPL based on UCLA-FDTD Design

Resonant frequencies

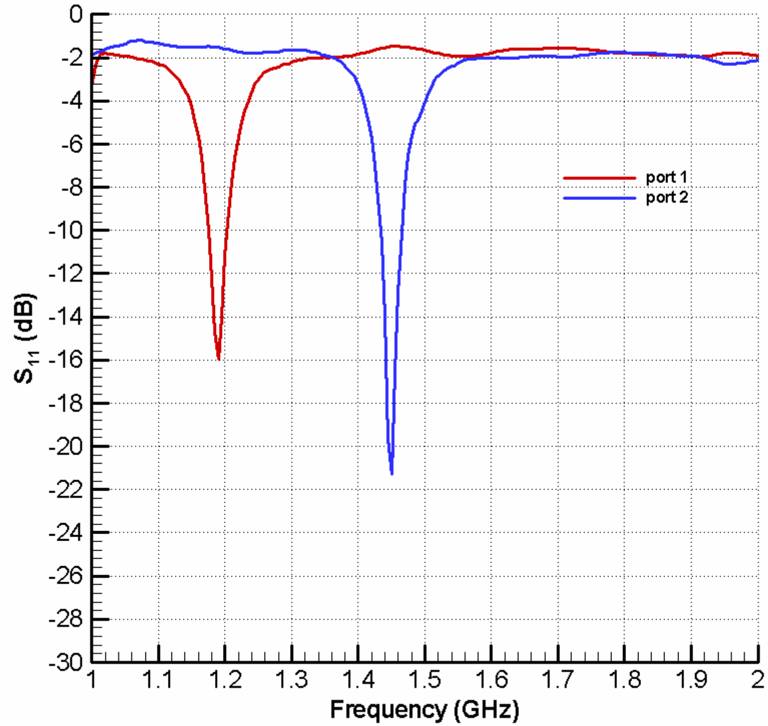
Lower patch: (1.26GHz)
Upper patch: (1.414GHz)

Return-Loss Measurement Results

(with larger ground-plane)



(with smaller ground-plane)



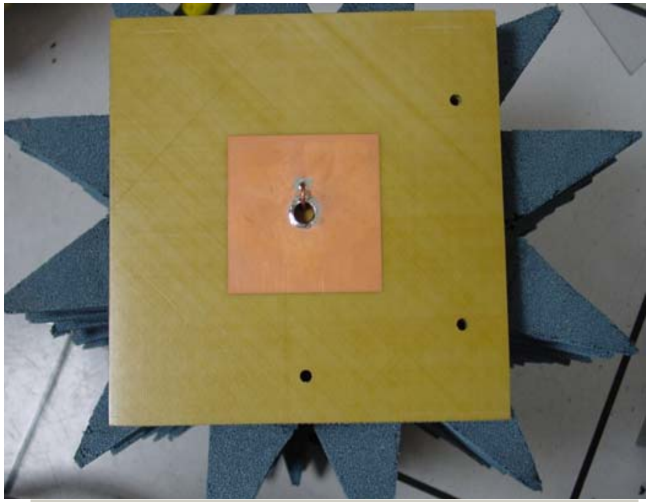
Port 1: Lower Patch, Port 2: Upper Patch

Port 1: Lower Patch, Port 2: Upper Patch

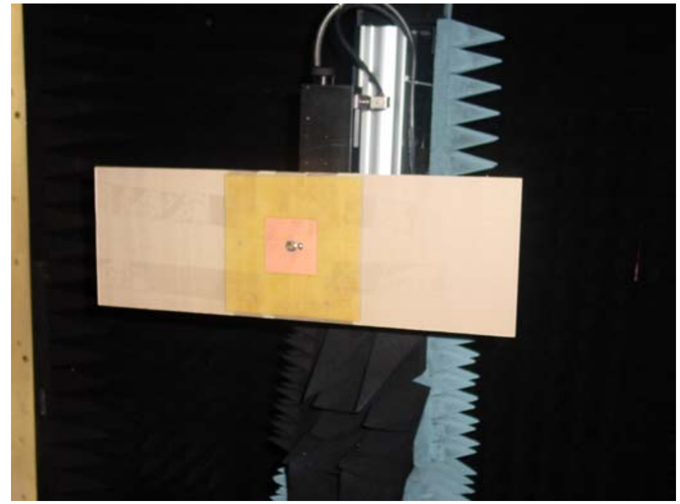
Lower Patch: Resonant Freq: 1.195GHz,Bandwidth: 25MHz
Upper Patch: Resonant Freq: 1.400GHz, Bandwidth: 25MHz

Lower Patch: Resonant Freq: 1.195GHz,Bandwidth: 30MHz
Upper Patch: Resonant Freq: 1.440GHz, Bandwidth: 33MHz

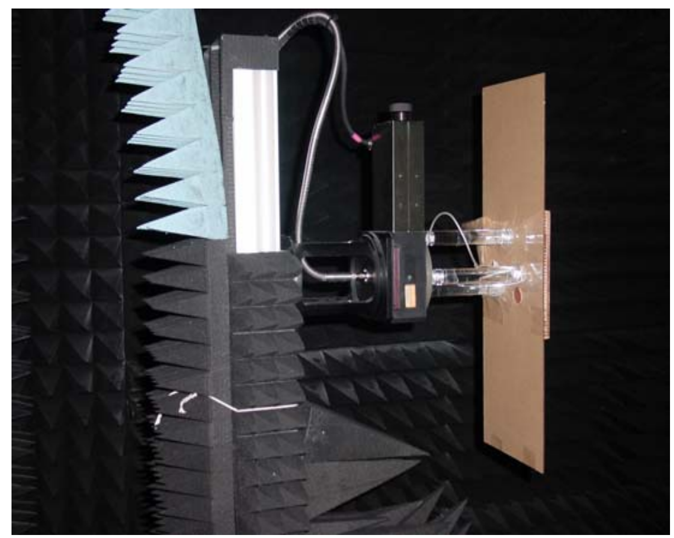
Near-Field Measurement Set-Up at UCLA



Stacked Patch (with larger ground-plane)

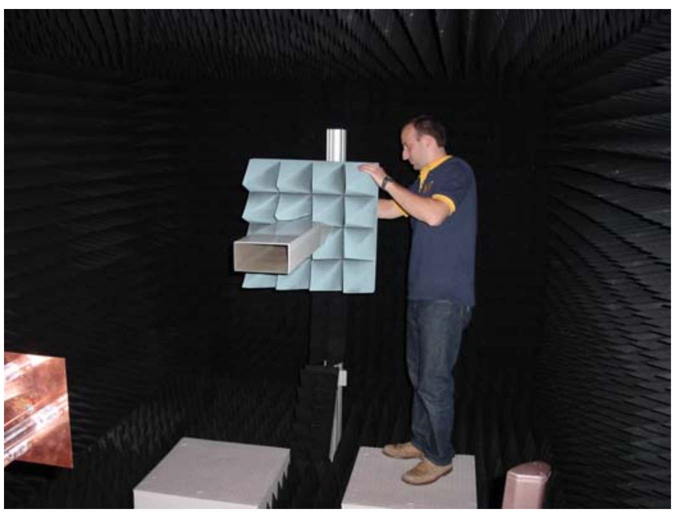


Front-view



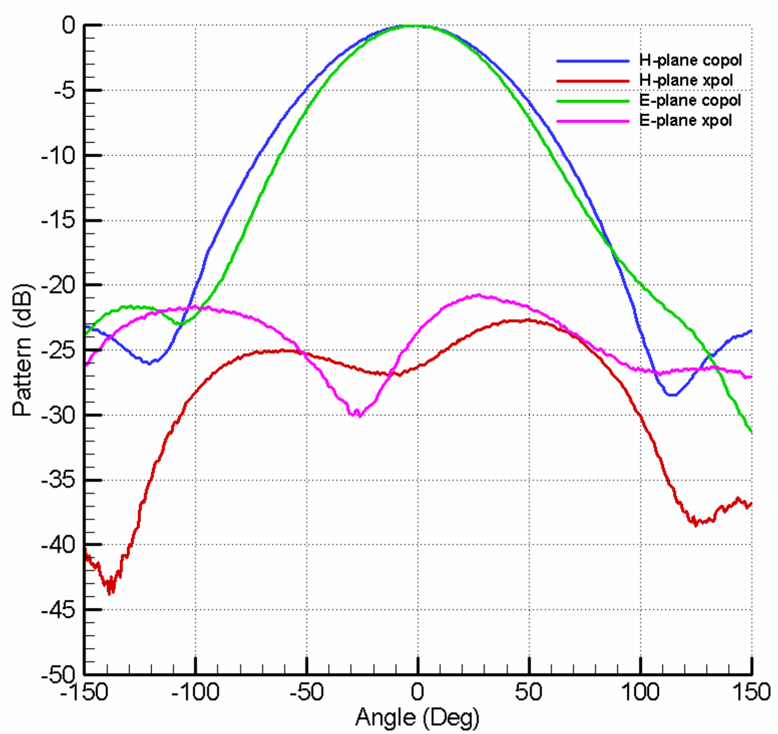
Side-view

Stacked Patch with fixture (Near-Field Measurement Chamber – UCLA)

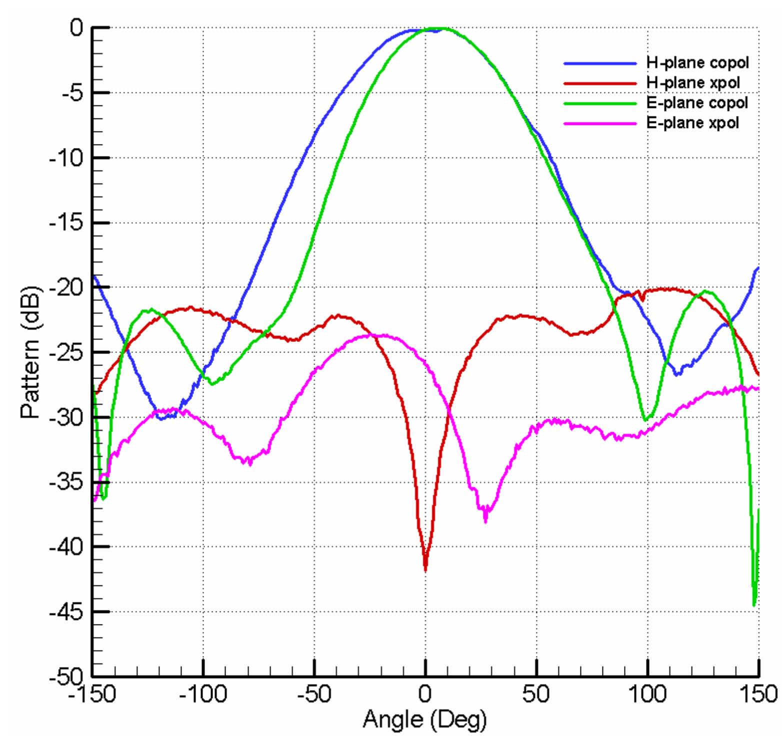


L-Band Probe used for Measurement

Pattern Measurement Results for Stacked Patch (With larger ground-plane: 21.5cm x 21.5cm)

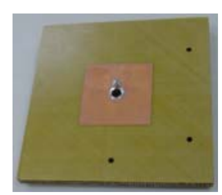


Lower Patch

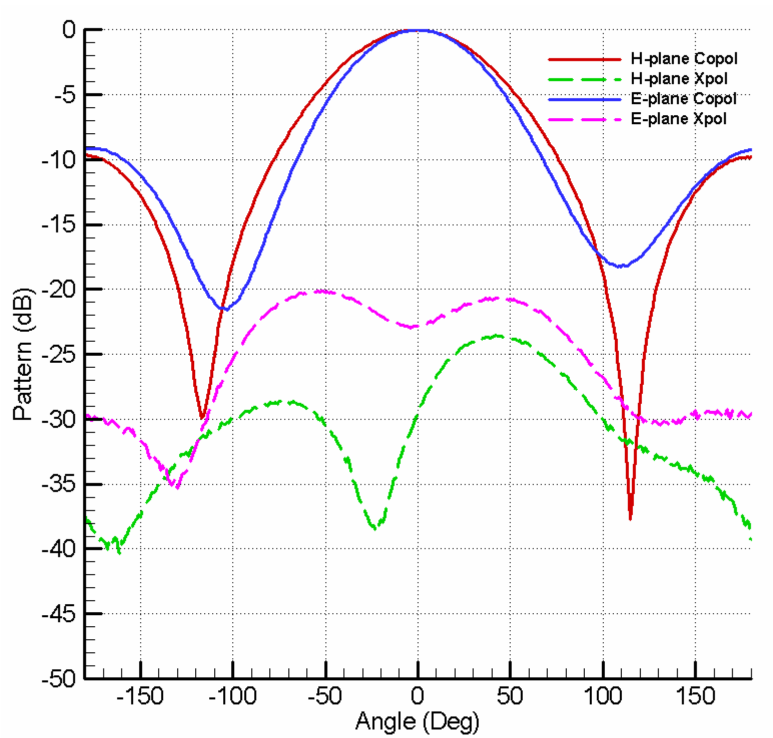


Upper Patch

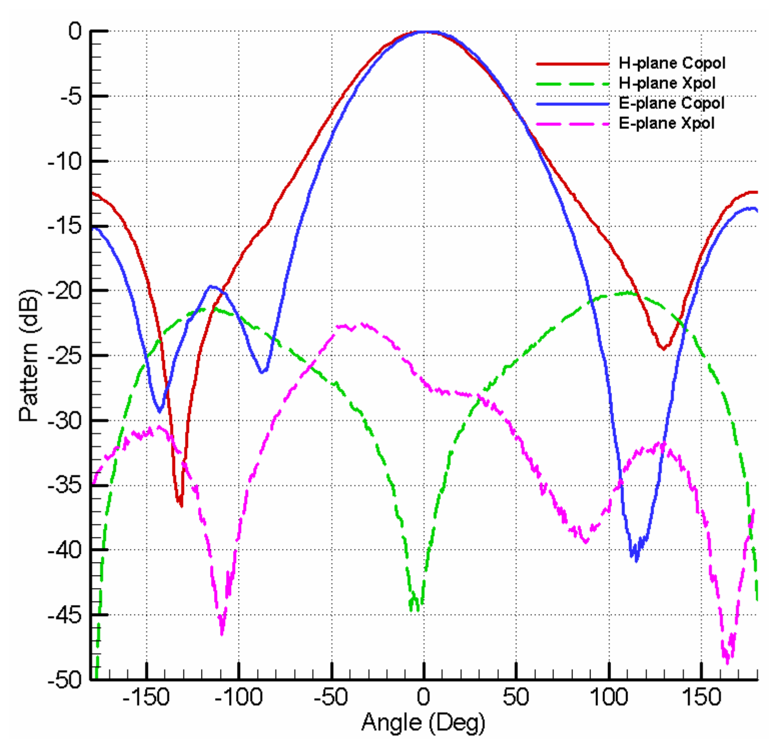
- Measurements were done at frequency with best match



Pattern Measurement Results for Stacked Patch (With smaller ground-plane: 11.8cm x 11.8cm)



Lower Patch



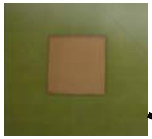
Upper Patch

- Measurements were done at frequency with best match

Microstrip Stacked-Patch Antenna Fabrication

Basic Construction: MSPA L-Band Antenna

Elements



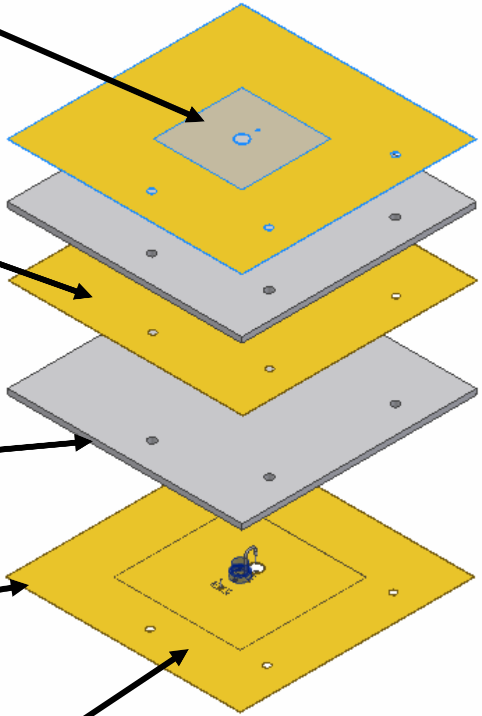
Circuit Structure - Upper Patch Layer

Circuit Structure - Lower Patch Layer

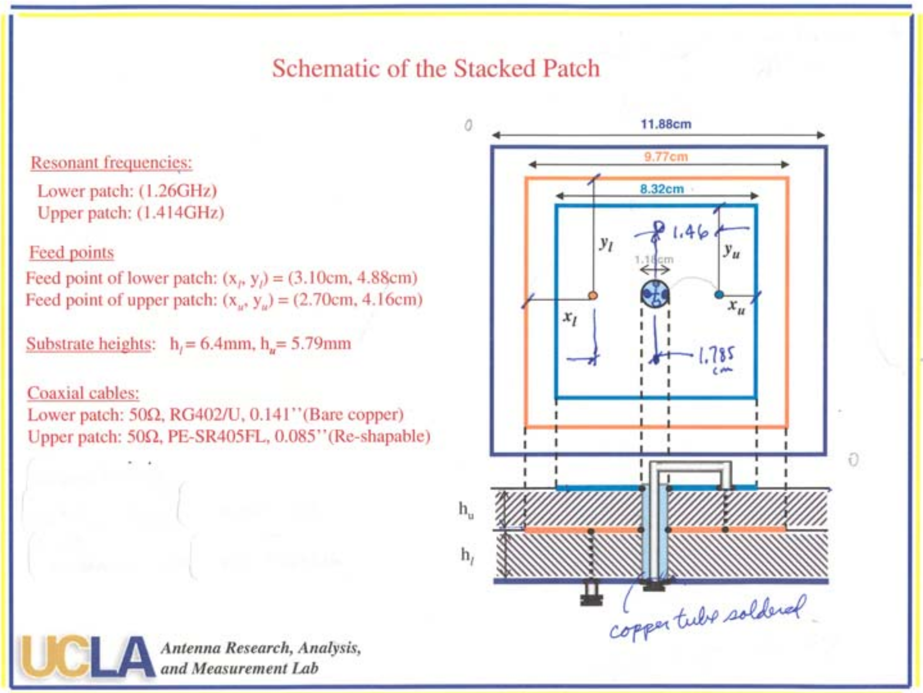
Honeycomb (gray)

Astro-Quartz (yellow)

Circuit Structure - Ground layer



Exploded View (prior to trimming)



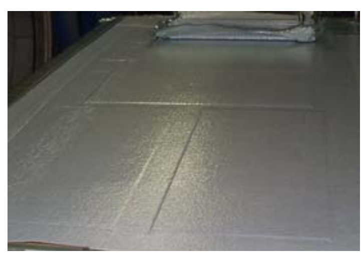
Schematic

Basic Construction: L-Band Antenna

Process - Lamination of Circuit Structures

Astro Quartz - Lay-up

Positioning Circuit Layers onto Astro Quartz

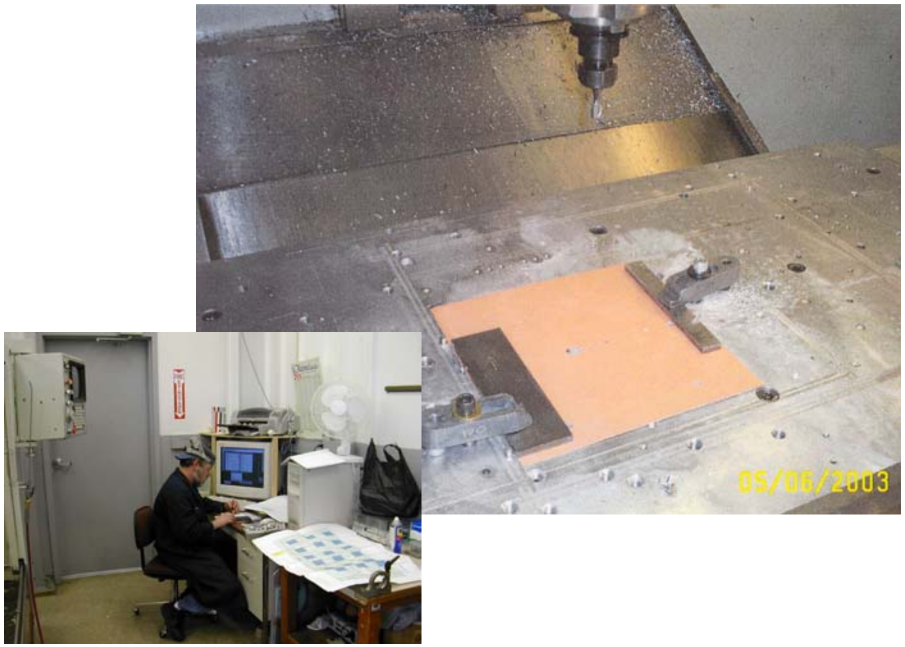


Vacuum Bag Preparation

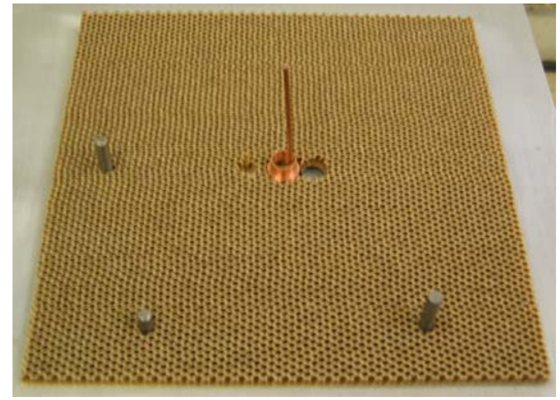
Autoclave Cure
120min / 350^{0}F @ 85 psi

Basic Construction: L-Band Antenna

Process - Material Preparation



Adding Feed Thru Holes
Patch Circuit Structures



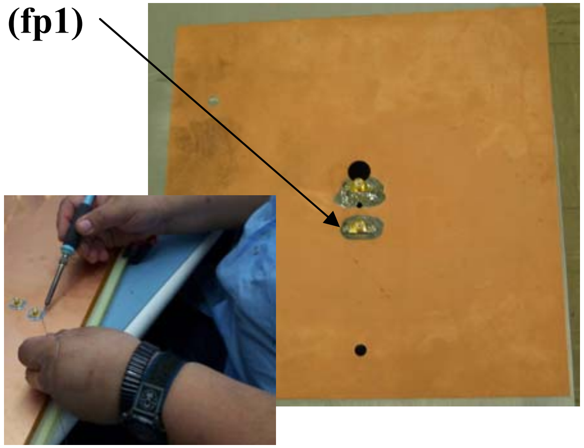
Korex - Adding Clearance Holes

Preparing Circuit Structures for Bonding

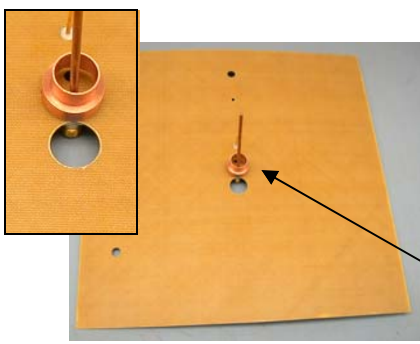
Basic Construction: L-Band Antenna

Installation of Connectors and EMI Tube

(fp1)

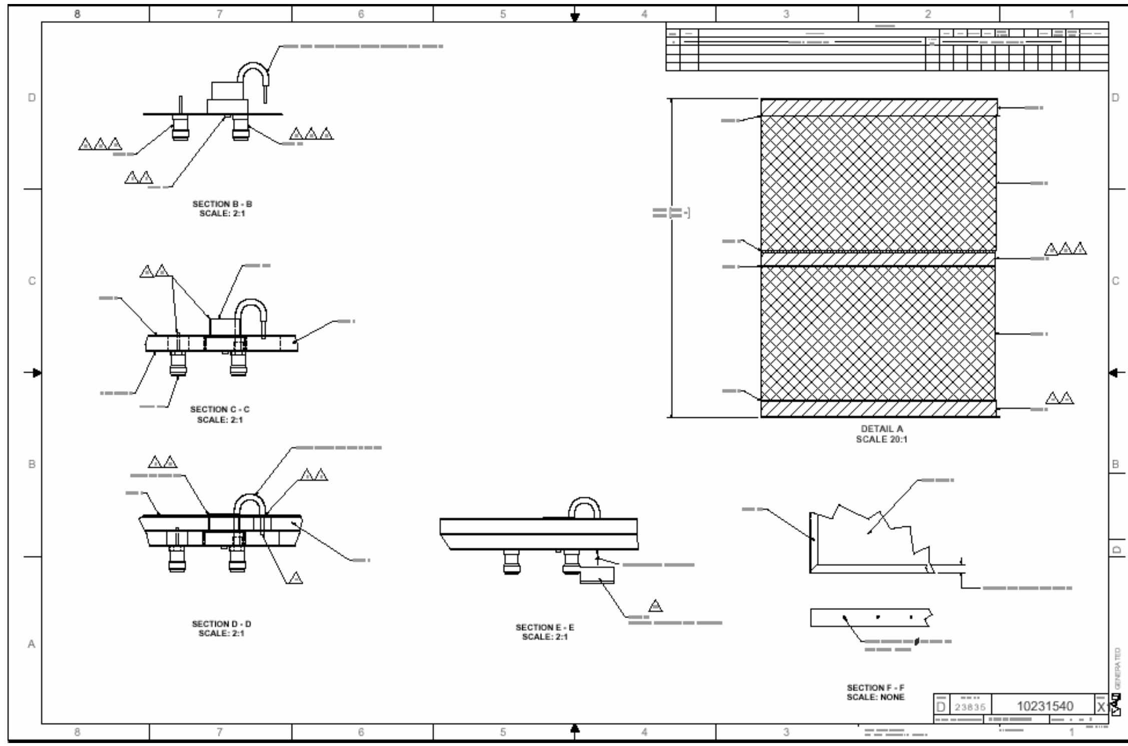


Connector Installation and Staking



(Tube)

Installation of EMI Tube

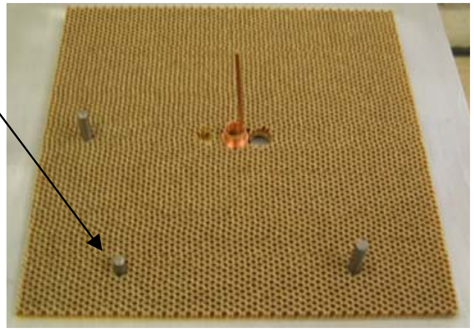


Assembly drawing showing installation sequence

Basic Construction: L-Band Antenna

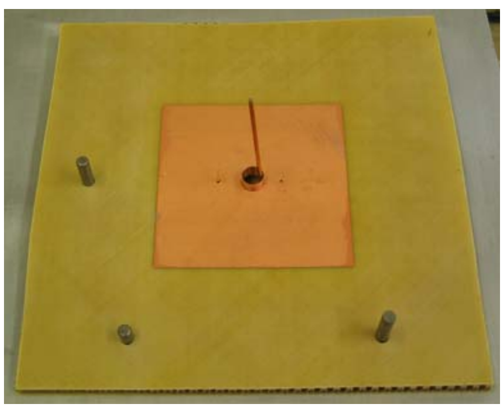
Process - Integration of Lower Circuit Patch

Tooling Alignment Pins

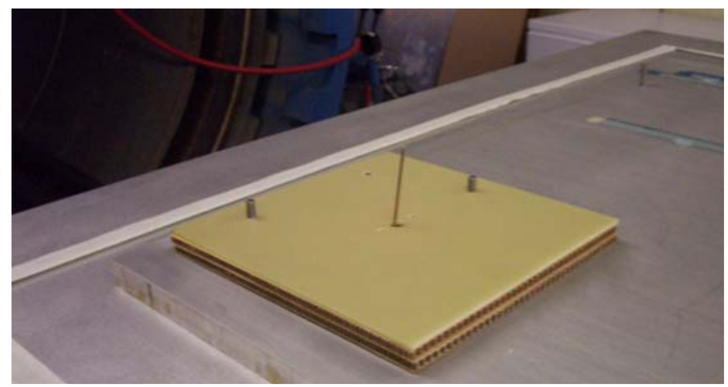


Over laying Korex onto Ground Plane Layer

Applying Film Adhesive



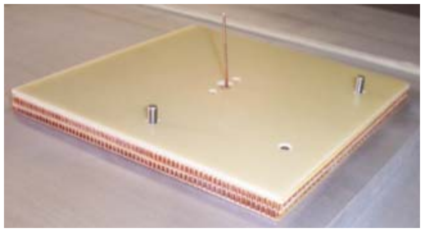
Over laying Lower Patch Layer onto Ground Plane Layer

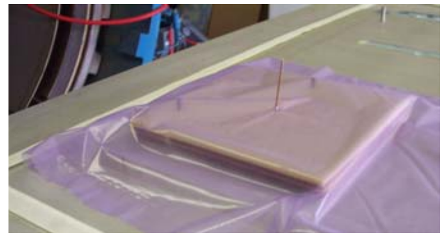


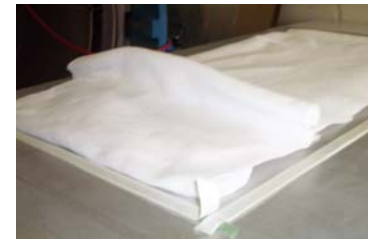
Prep Tool and Antenna for bagging

Basic Construction: L-Band Antenna

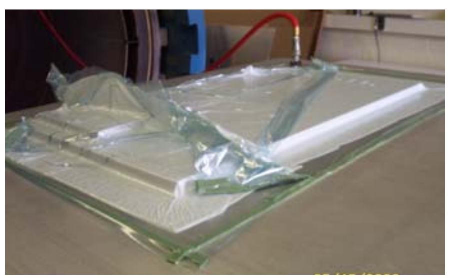
Process - Integration of Lower Circuit Patch (con't)







Vacuum Bag Preparation



Applying Vacuum @ 14.7 PSI

Oven Cure 2 hrs @ 350^0F

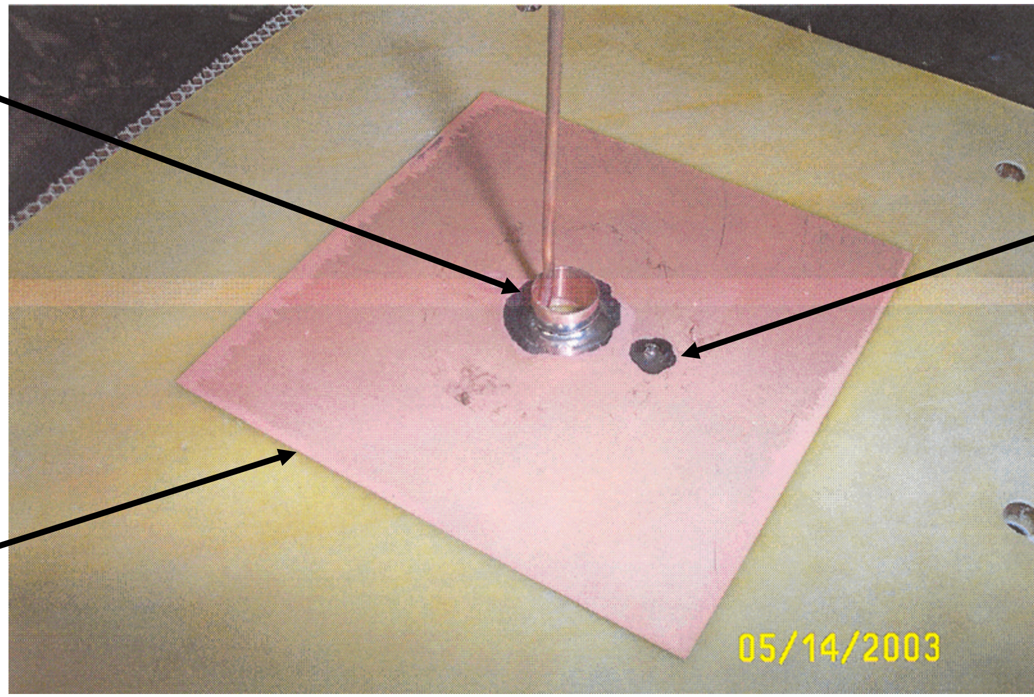
Basic Construction: L-Band Antenna

Installation of EMI Tube and fp1

EMI Tube soldered to Lower Patch

fp1 soldered connection

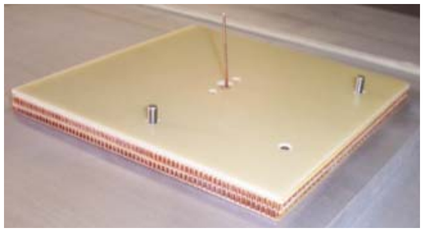
Lower Circuit Patch size: 9.77cm^2

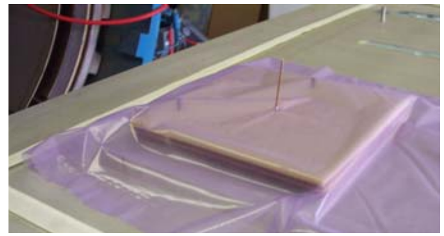


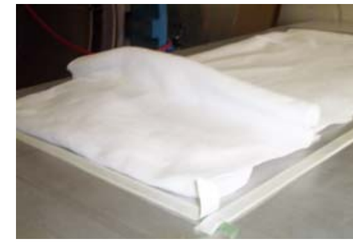
Lower Patch Assembly

Basic Construction: L-Band Antenna

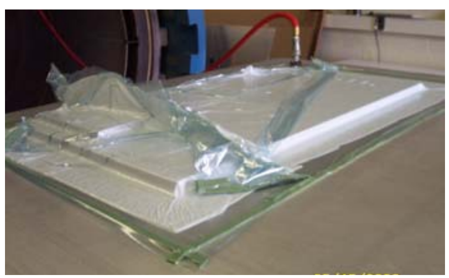
Process - Integration of Upper Circuit Patch







Vacuum Bag Preparation



Applying Vacuum @ 14.7 PSI

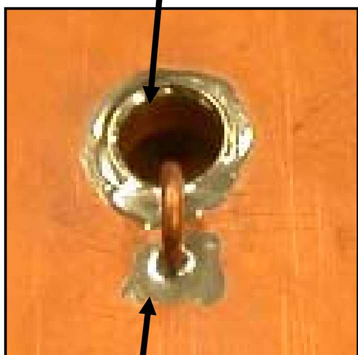
Oven Cure 2 hrs @ 350^0F

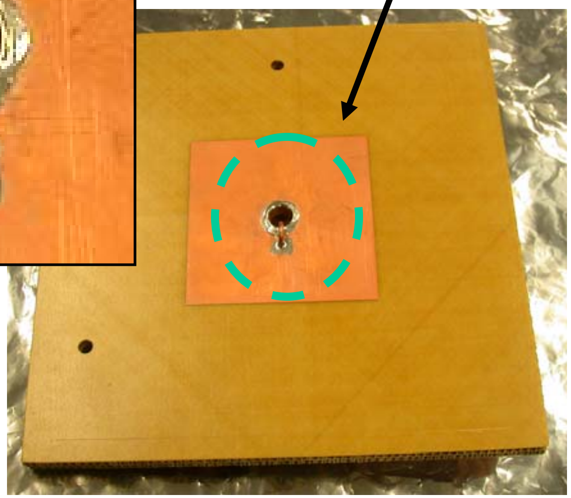
Basic Construction: L-Band Antenna

Installation of fp2

EMI Tube soldered to Upper Patch

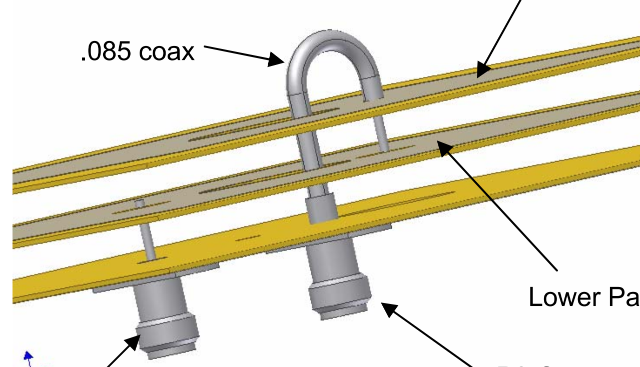
Upper Circuit Patch size: 8.32cm^2





Upper Patch Assembly

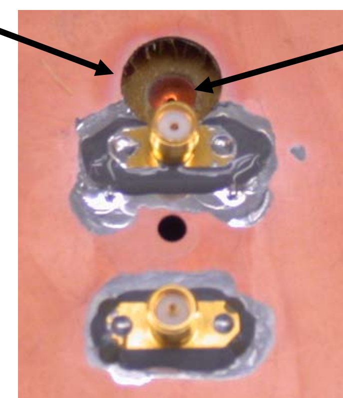
fp2 soldered coax connection



3D of fp2 connection

port

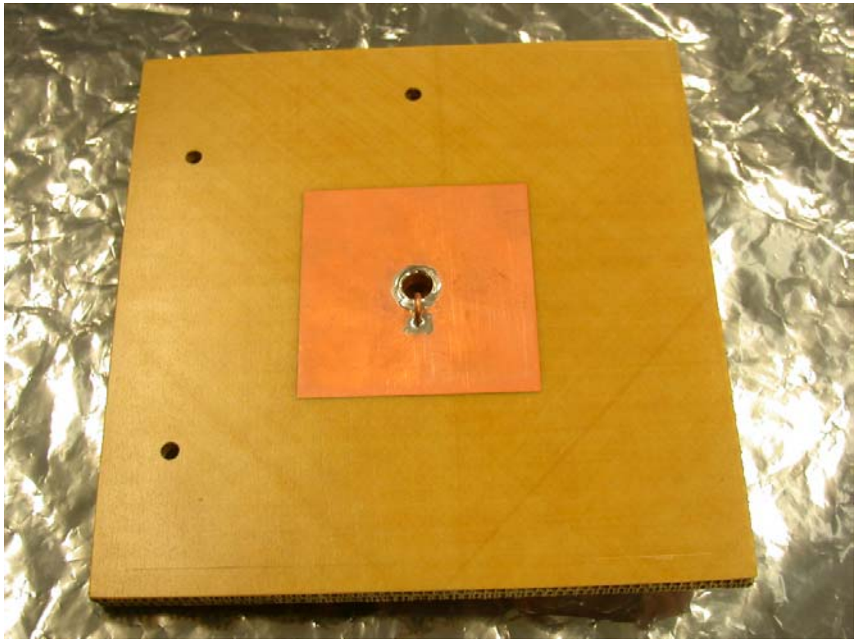
fp2 connection



Ground plane View of fp2 to lower patch connection

Basic Construction: L-Band Antenna

Finished product



Upper Circuit Side

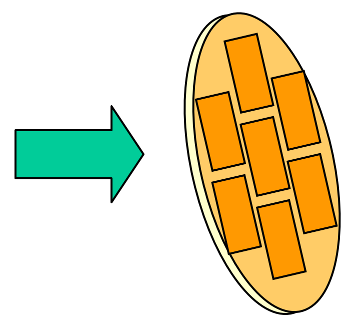
Ground Plane Side

Summary

- Demonstrated the microstrip stacked-patch with center-feeding concept for dual-frequency operations
  - A single polarization, dual-frequency patch was designed, built and tested
  - Simulation and testing show good correlation

Future Work

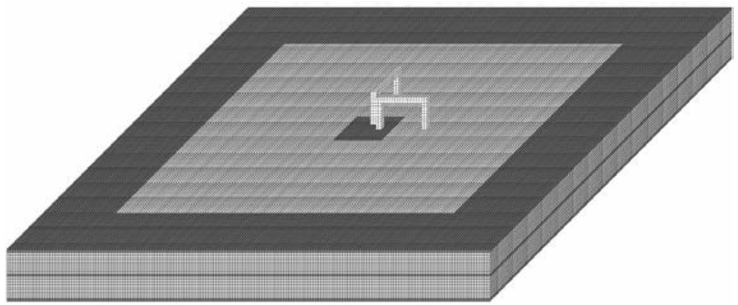
- Near Term
  - Ready to fabricate and test dual-polarization microstrip stacked-patch (July-August)
    - Include two additional feeds in the design
    - Use the same fabrication process
  - Start the array design in September
- Proceed to next phase
- Explore the airborne science instrumentation using the MSPA for the antenna to fly on UAV and P-3



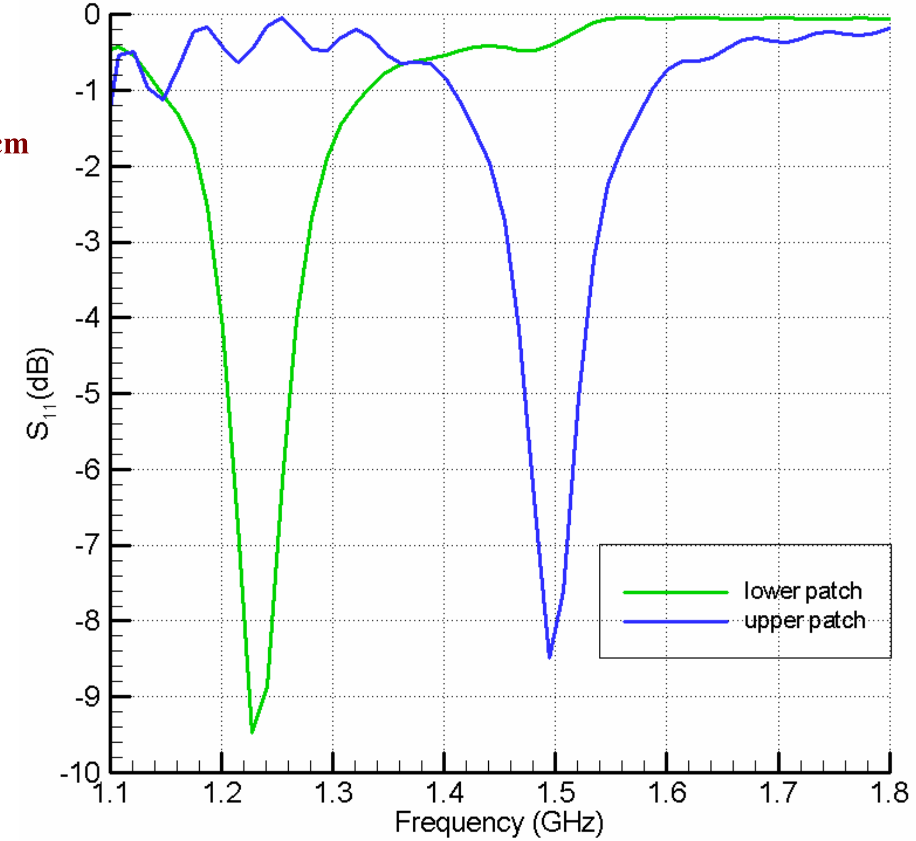
Backup

Return-Loss Simulation Results for the Complete Stacked-Patch Geometry (with two feeds for dual-polarization)

<u>Simulation Results</u>:
Cell size: 0.066cm, Coax size: 0.132cm(dia), Size of tube: 1.18cm
Resonant frequency upper patch: 1.492GHz, S_{11} : -8.485dB
Resonant frequency lower patch: 1.227GHz, S_{11} : - 9.483dB



Grid used in FDTD

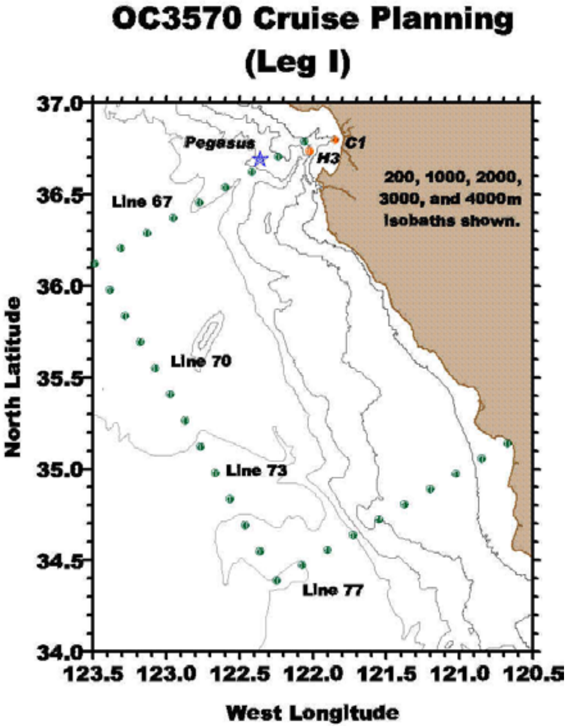


Return-loss simulation results

PRECISION RADIOMETER MEASUREMENTS FOR REMOTE SENSING OF OCEAN SALINITY

NCAR C-130 aircraft used for PALS Mission

Passive Active L/S-band (PALS) Instrument on the C-130 aircraft



Area of Sea Surface Salinity (SSS) measurements made from July 14 to 19, 2002, which is West and South of Monterey CA. The Pt. Sur ship measured the SSS and Sea Surface Temperature (SST).